Self-Adaptive Pregnancy Health Monitoring System

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Abstract- *Pregnancy is a critical stage in each women's life. Every day nearly 830 women die due to pregnancy complications. In the majority of the developing countries and the smart cities, medical systems are not centralized for sharing the information. Especially in rural areas pregnant women are not able to do their customary check-ups at the first trimester of pregnancy. This causes higher mortality rate of infant and mother. The existing method is not sufficient for pregnant women in all health conditions especially when they are bedridden, working or in remote areas. To overcome this medical emergency, in the proposed work a self-adaptive pregnancy monitoring system with sensor network and IoT is introduced to monitor both mother and foetus health condition, it includes some of the vital parameters such as the temperature, heart rate and blood pressure which helps in determining conditions like Chronic and gestational hypertensions, reduced foetal movement and foetal heart rate. The measured parameters through sensors are sent to the doctor via SMS and also other additional pieces of information such as morning sickness symptoms and previous medical history of the patient that helps in determining conditions like Hyperemesis Gravidarum, pregnancy loss, stillbirth and preterm labour will be uploaded to the web application which can be accessed directly by the doctor using IoT. The proposed architecture concerns in developing a compact device for assisting pregnant women in all circumstance that helps them in monitoring their health as well as the foetal heath with costeffective recent sensors and internet of things.*

Keywords- Adaptive Monitoring, Internet of Things, Web Application, Personalized Care, Vital parameters.

I. INTRODUCTION

Pregnancy is a very important stage in every women's life [1]. Pregnant Women are neither patients nor person with optional health care. The change in environment, socio-economic rankings and religious beliefs can also affect women's health during pregnancy [3]. It was estimated roughly that 30,3000 women died during pregnancy and childbirth. Most of those deaths occurred because of low-resource settings, and almost allof them could have been prevented. Majority of the maternal deaths (99%) occur in developing countries It is because of complications throughout the pregnancy and childbirth. The leading cause of foetal death is maternal infections such as HIV, Syphilis, Haemophilus Influenza and intrauterine foetal growth restrictions.

Some of the gestational medical conditions such as Hyperemesis Gravidarum, Chronic Hypertension, Gestational Hypertension, gestational diabetes, Eclampsia and Preeclampsia symptoms may become serious risk factors if proper attention is not given during pregnancy. Most of these medical conditions develop throughout pregnancy and are treatable. Different complications could exist before pregnancy but they are worsened throughout pregnancy, particularly if not managed as part of the woman's care [2]. Few factors that prevent women from receiving or seeking care during pregnancy and childbirth are Poverty, distance, lack of information, inadequate services, cultural practices and religious beliefs. Therefore, necessary efforts should be taken by providing timely and quality health assistance to pregnant ladies which will lead to the birth of healthy children [4].

Till date, there is no such dedicated health monitoring facility available to meet the need for pregnant women. The proposed work integrates body sensors, mobile device of pregnant women and health professionals and also web application [1][2][5]. It provides adaptive health care assistance for women based on their changing health observations which are analysed by the doctor or health care professionals and then proper directions will be given to women. Health professionals utilize web applications so that they can visualize the women data as per the requirement.

II. PROBLEM STATEMENT

Pregnant women are usually at higher risk when compare to non-pregnant women pregnant women experience various health conditions throughout gestation such as Chronic and gestational Hypertension, Hyperemesis Gravidarum preterm labour, stillbirth, Anaemia, Pregnancy loss or Miscarriage, Reduced foetal movements and heart rate [7]. The traditional health monitoring system is not flexible for women in every condition especially when women are bedridden, working or in remote areas where health-care units

are unavailable. The inconvenience in present health monitoring can be avoided by using adaptive monitoring and real-time monitoring [1][8]. The possible health conditions vs weeks in the pregnancy are shown in table 1.

Table 1. Possible Health Conditions vs Weeks in Pregnancy

Possible Health Conditions	Week in Pregnancy
Chronic Hypertension	4-18
Gestational Hypertension	18->38
Hyperemesis Gravidarum	4-20
Preterm labour	20-36
Reduced foetal movement	24-36

III. PROPOSED SYSTEM

The proposed system can perform the adaptive and real time health monitoring of pregnant women. The monitoring system co-exists with a mobile system, i.e., the communication system architecture. The web application is accessible by both admin as well as health care professionals and necessary inputs can be uploaded by both women and health care professionals.

A. Adaptive Health Monitoring

Adaptive monitoring is an effective and new level paradigm. It analyses the dynamics of foetal growth and pregnant woman's health indicators like physical function and vitality for the need for adaptation.

The head circumference and weight lead to irregular growth throughout the pregnancy [1]. Changes in the body of pregnant women during the pregnancy can be observed some physiological changes that occur during different phases of the gestational period. physical aspects and vital parameter play an important role in the health of a person. Both physical aspects and vital parameter of pregnant women [6].

To overcome this irregular growth in pregnancy requires an adaptive health monitoring system. Adaptive health monitoring system adapts itself to the real time and provides appropriate and accuracy in the diagnostic can be assured. changes from the time of conception to the delivery. Adaptivity is the most unique feature of the proposed prototype. Our focus is to make this system as comprehensive as possible for pregnancy.

B. Sensor Management

The sensors which are used in this architecture helps in detecting the physical property and measures the health parameters of pregnant women. This module is responsible for the generation of input data for the system.

There are basically two types of sensors which are used. They are body sensors and ambient or environment sensor. Here the body sensor made up of multiple set of sensors that are placed near cuff which helps in detecting Blood Pressure (Systolic Diastolic), Heart Rate of the pregnant women. EMG sensor is adapted to detect the uterine contractions of a lady during the preterm labour. The ambient sensor includes the temperature sensor which helps in detecting the body temperature of women.

The foetal growth and foetal heart rate come under the foetal health monitoring where foetal movement can be obtained from the input of the women itself and her feedback is taken into consideration to determine foetal movement. Women are given with a button pad and by when she feels the movement of the foetus, she gives the feedback by pressing it, the increment value is taken as average foetal movement or foetal kick. One more ambient sensor is used to detect the foetal heart rate is a condenser mic. The input is taken from the condenser mic by placing it on the abdomen of women and the obtained output is pre-amplified and filtered using Butterworth filter and data is analysed. The sensors used and the parameters identified by them and conditions recognized are shown in table3.

Table 2. Parameters and Normal values

Parameters	Normal Value
Heart rate	70-90 beats/minute
Foetal Heart rate	110-160 beats/minute
Blood pressure	120/80 mm Hg
Temperature	37.8^{0} Celsius
Uterine Contraction	Amplitude 30mm Hg, Frequency Increases 3-4 per minute

The parameter values obtained from the sensors are studied by health care professionals in determining maternal and foetus health condition. If the values of the parameters obtained from the sensor deviates from the normal values then it indicates a medical emergency. The basic parameter detected by the sensor and their normal values are shown in table 2.

Table 3. Sensors vs parameters vs conditions faced.

Sensors	Parameters	Conditions
ECG Sensor	Heart rate	For routine check-up
EHG sensor/EMG Sensor	Uterine Contraction	Preterm Labour
Blood pressure kit	Blood pressure	Chronic Hypertension, Gestational Hypertension
Condenser mic	Foetal heart rate	Foetal heart rate
Input button	Foetal Movement	Reduced foetal movement

C. Computation And Analysis

The temperature sensor, heart rate sensor, blood pressure sensor, EMG sensor foetal heart rate and foetal movement are controlled by using an Arduino controller. The data from the sensors are being analysed by the controller and the results are being simulated and send data results via SMS to medical practitioners. The obtained data and the inputs from pregnant women are uploaded to the web application by the user/admin.

The Arduino UNO is an ATmega328 based microcontroller board which has 6 analogue inputs, 14 digital input/output pins. It also has a 16 MHz crystal oscillator, a USB, a power jack, an ICSP header, and a reset button. Since sensor values are analogue signals, it can be directly connected to the analogue input pin. ADC in this Arduino microcontroller will convert analogue signals to a digital signal before any further process can be done. The Arduino UNO microcontroller will process the signal and the output will be in digital signal voltage form. The basic flow of the architecture is shown in figure 1.

D. Communication Module

In this architecture, the communication is established between the user and the doctor/health care practitioners through SIM 800 GSM module. GSM Module has to be interfaced with the microcontroller to send a message or to contact. SIM 800 helps in cellular communication i.e., making calls, sending email and SMS text and even connects to the internet. It needs external peripheral to function properly, considering that mobile devices are becoming increasingly more pervasive so much so that they are considered extended self of the person, therefore making it a preferred choice gateway for the body sensors.

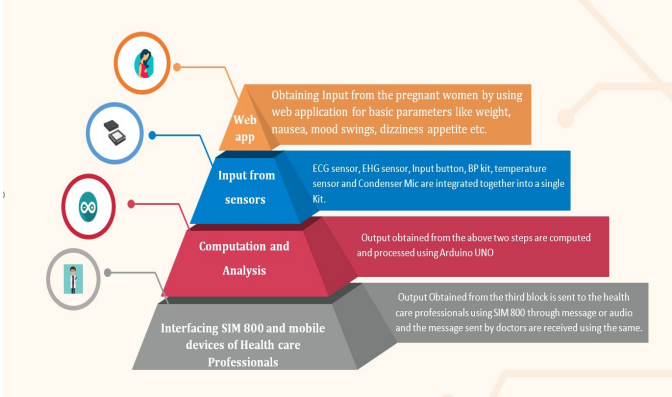

Figure 1. Basic flow of architecture

E. Web Application

IoT enables healthcare professionals to be more watchful and connect with the patients proactively. In this web application the admin (pregnant women) login by using user id and password and fills the detail of their symptoms and status. On the other end, health care professionals can log in and check the details filled by women. The web application can be designed using programming languages like server script PHP and in the front end by using HTML, CSS and java Script. The basic block diagram of the web application is shown in figure 2 and 3.

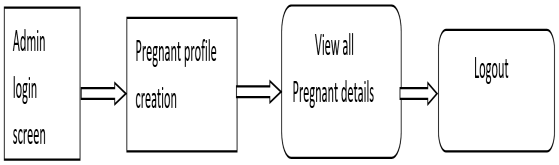

Figure 2. Block diagram of Admin login web app

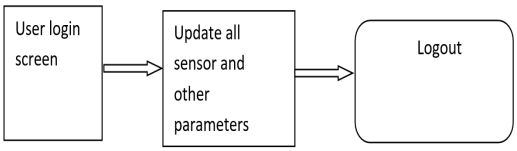

Figure 3. Block diagram of user login web app

F. Block Diagram

The proposed architecture contains the sensor arrangement through which all the basic parameters of pregnant women are taken. Obtained data is computed and processed to obtain digital data and this digital data is sent to the health care professionals. The block diagram of the proposed architecture is shown in figure4.

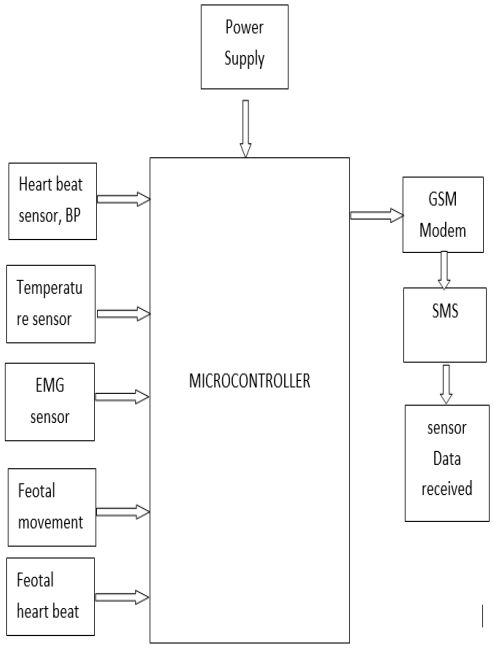

Figure 4. Block diagram of proposed architecture

IV. CONCLUSION

Most studies on maternal mortality are based on hospital records, However, in developing and underdeveloped countries, there is still the practice of conducting delivery at home this health negligence and lack of proper attention also cause considerable mortality rate. To avoid these complications, the proposed architecture describes a compact assistive device which helps in monitoring the vital parameters such as the temperature, blood pressure, heart rate and uterine contractions of women and heart rate & movement of the foetus by using different sensors. The device is lightweight, portable, highly sensitive even for small movements and affordable by all the classes of society, thus preferred as a home monitoring device. Regular monitoring of maternal and foetal vital parameters in the rural areas reduces the infant as well as maternal mortality rate. The measured parameters are transferred through the IoT web application either through admin/patient there by providing quality and timely health assistance for both foetus& mother and also helps in maintaining the record (centralized information) of the women medical history

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